Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

9.9
764Un
p. 2

FOREST SERVICE
U.S. DEPARTMENT OF AGRICULTURE
INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION
507 — 25th Street, Ogden, Utah 84401

USDA Forest Service
Research Note INT-235

October 1977

ALASKAN LIGHTNING STORM CHARACTERISTICS

R. G. Baughman and C. W. Schmid, Jr.[1]

ABSTRACT

The characteristics of 23 cumulus congestus clouds were investigated in interior Alaska during the summer of 1973. Results show Alaskan lightning storms are generally smaller, more isolated, and produce less lightning than western Montana storms. Nine storms produced 123 lightning discharges of which only 8 were cloud-to-ground. Only 1 discharge was recorded with long-continuing current of 40 milliseconds in duration (the type known to start fires in Montana). No lightning-caused fires were reported within many miles of the observed storms. This small sample of Alaskan storms exhibited characteristics that are not conducive to producing large numbers of wildfires.

KEYWORDS: thunderstorms, lightning, fire.

Although lightning is a common cause of wildfire in Alaska, very little is known of the characteristics of individual Alaskan storms and of the accompanying lightning. Therefore, this report is an effort to partially fill this knowledge void. The information reported here was obtained as part of a USDA Forest Service evaluation of a Bureau of Land Management (BLM) program to suppress wildfire by the modification of convective clouds. Although our prime objective was to evaluate the effectiveness of the BLM-sponsored cloud seeding, the supporting data provided valuable information about Alaskan storms, including measurements of individual lightning discharges.

---

[1] Respectively, research meteorologist and formerly research physicist, located at the Intermountain Station's Northern Forest Fire Laboratory, Missoula, Montana.

INSTRUMENTATION AND OBSERVATIONS

In agreement with established nomenclature (Uman, 1969), we call any discharge that does not reach earth an intracloud (ic) discharge or cloud-to-cloud discharge, and those that do reach earth cloud-to-ground (cg) discharges. The very high current component of a cg discharge is called a return stroke. Some lightning discharges contain one or more return strokes that terminate in one-thousandth of a second or less, other lightning exhibits continuing current flow for a few hundredths to one- or two-tenths of a second after a return stroke. Lightning discharges with continuing current of 40 or more milliseconds (ms) are called long-continuing current discharges (LCC) (Fuquay and others 1972).

An instrumented, twin-engined, turbocharged, pressurized aircraft served as the data-gathering platform. The airborne recording system consisted of four lightning sensors, a magnetic tape recorder, and supporting electronics. The sensors produced analog signals that were recorded on magnetic tape and later reproduced on a high-speed oscillograph.

The measurements included the electrostatic and radiation fields of lightning. The electrostatic measurements are of two forms: (1) slow changes in time up to hundreds of milliseconds (slow Delta E), and (2) rapid changes in the order of a few milliseconds (fast Delta E). The electrostatic unit consisted of a plate antenna and charge amplifier with a 2-second time constant mounted on the right wingtip and a signal processing unit in the airborne console. In the console, the antenna signal was directly amplified and recorded as slow Delta E and also differentiated on a 5-ms time constant as fast Delta E. The slow and fast Delta E were our primary identifiers of all lightning (Hawe and Fuquay 1969).

This unit detects changes in the electrostatic field due to lightning discharges up to a maximum range of about 20 miles. A VLF antenna mounted on the belly of the aircraft coupled with a receiver tuned to 8 kHz was used to record the VLF radiation field associated with lightning. The output from this unit helped identify cloud-to-ground return strokes (Uman 1969). We also recorded the VHF radiation field at 50 mHz. The VHF unit was used primarily to differentiate between ic and cg lightning. With our system we are able to detect lightning, discriminate between intracloud and cloud-to-ground lightning, count return strokes, and determine the frequency and time duration of continuing current in cg lightning.

In addition to lightning measurements, we observed other cloud phenomena such as temperature and height of cloud bases, height of cloud tops, occurrence of glaciation, and general weather conditions. In accordance with our primary objectives, we focused attention on potential storms in the form of cumulus congestus clouds and, except in one case, avoided ongoing mature storms. As a result, our observations included some clouds that on occasion did not exhibit electric fields or produce lightning. When lightning did occur, we were able to continuously observe the total lightning activity of all storms. Storm observations ranged from near McGrath in the southwest part of interior Alaska, east to the Canadian border, and as far north as the Chandalar River on the south slope of the Brooks Range (67° N lat.). Some 23 clouds were investigated, including 10 clouds seeded with silver iodide; however, unless otherwise noted, the data reported here are from unseeded clouds.

RESULTS

Our results show Alaskan lightning storms to be smaller physically and electrically and more isolated than western Montana storms (for information on Montana storms, see Fuquay 1967). The relative isolation of Alaskan storms was reflected in the ease of maneuvering the aircraft to maintain a favorable position of 1 to 3 miles from an individual cloud at elevations of about 18,000 to 20,000 feet m.s.l. for periods of 15 to 45 minutes. Figure 1 is an example of an isolated lightning storm.

Figure 1.--An example of an isolated lightning storm photographed at 1140 Alaskan daylight time, June 29, 48 miles from Fort Yukon on 120° radial. Aircraft at 22,300 feet.

Favorable recording positions were maintained for 20 of the 23 data clouds throughout the entire recording periods. Smooth flying was experienced at observation height at all times. Cloud-top height of the lightning storms ranged from 20,000 to 33,000 feet, with a median of 25,000 feet for seven observations. Top height was estimated visually from our 18,000 to 20,000 foot position, except in the case of the 33,000-foot cloud, which was measured by a BLM fire patrol jet aircraft. Cloud base heights ranged from 3,500 to 7,000 feet, with a median of 6,000 feet for eight observations (including five seeded clouds). Base temperatures ranged from +3° C at 7,000 feet to +15° C at 3,500 feet (uncorrected aircraft thermometer). Cloud diameters observed in five penetrations by seeding aircraft near the time of first lightning ranged from 1.2 to 3.5 nautical miles. Cirrus was always encountered extending out from parent lightning storms while high level cirrus (well above cumulus cloud tops) was often noted (7 out of 9 observation days).

Clouds in an advanced stage of glaciation (transformation of liquid water to ice) that extended above 18,000 feet always had either a very weak electric field or no electric field and did not produce lightning. Figure 2, an example of a towering cumulus reaching 18,000 feet, shows the fibrous outline of glaciation with no lightning. On the other hand, 3 clouds (of the 23 data clouds) extending above 18,000 feet (temperature level of -17° C) with little or no visual glaciation at initial contact also produce no electric fields or lightning. Four other clouds extending above 23,000 feet (-26° to -28° C) with no visual initial glaciation exhibited strong electric field; two produced no lightning while the other two produced only one discharge each.

These observations suggest that potential Alaskan lightning storms can be characterized as cumulus clouds that are not extensively glaciated at 18,000 feet but upon reaching 23,000 feet possesses a dense cauliflower shape with strong electric fields. This agrees with Alaskan weather modification forecasting procedures where the potential for lightning is deemed to exist when cloud tops reach the -28° C temperature level (Cooper and Heikes 1973).

Lightning recordings suggest that Alaskan storms are not overly active. The amount of lightning produced by individual storms varied from a low of 1 discharge to a high of 53 discharges, with a median of 5 discharges for nine unseeded storms. Lightning activity ranged from 1 minute 22 seconds (2 discharges) to 45 minutes 6 seconds (24 discharges), and the rate of lightning varied from 0.11 per minute to a high of 1.5 per minute.

The largest storm we observed in Alaska was a seeded storm that produced 66 discharges during 65 minutes. The nine unseeded storms produced a total of 110 intracloud, 8 cloud-to-ground, and 5 unidentified discharges. The 8 cg discharges made up only 6 percent of the total, whereas in Montana storms about 25 percent of all discharges are cg (Fuquay and Baughman 1969). This also differs from results of other work where it is suggested that the higher the latitude, the higher the proportion of cg lightning (Pierce 1970). Seven of the eight cg discharges produced only one return stroke each, while the remaining discharge produced five return strokes.

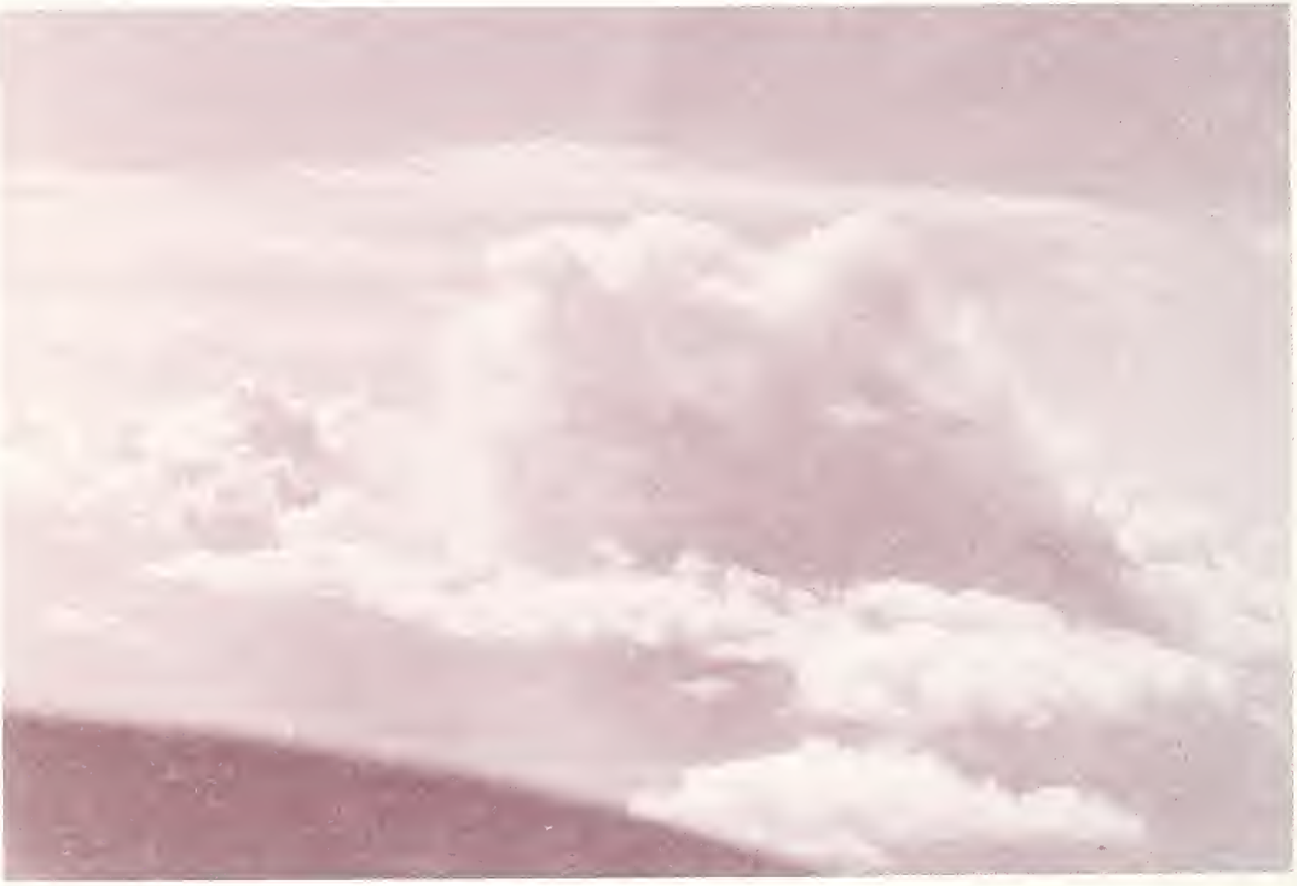

Figure 2.--An example of a towering cumulus reaching 18,000 feet that shows the fibrous outlines of glaciation with no lightning (photographed at 1542 Alaskan daylight time on June 15 about 50 miles from Fairbanks on 050° magnetic radial. Aircraft at 17,600 feet.

As a comparison, western Montana cg lightning averaged four return strokes per discharge (Fuquay and Baughman 1969). The decrease in the average number of return strokes per discharge with latitude was predicted by Pierce who also stated that a considerable statistical sample is necessary to establish satisfactory average values for particular geographic locations. The 8 Alaskan cg discharges did not produce the long-continuing current observed in Montana fire-setting lightning (Fuquay and others 1972); however, continuing current greater than 5 ms and less than 26 ms was recorded. Discharges from the seeded storms also exhibited continuing currents, at least one of which exceeded 40 ms. No lightning-caused fires were reported within many miles of the storms considered here. The lack of cg lightning, the tendency to produce only one return stroke per discharge, and the absence of long-continuing current discharges probably contributes to the production of fewer fires in Alaska than would occur with more severe storms. The frequency of recorded lightning is given in table 1.

As a result of our observations, we hypothesize that in some years Alaskan storms are more active electrically during the morning or early afternoon hours than later in the afternoon. This hypothesis is supported by the data given in table 1, where the total amount of lightning for clouds exhibiting electric fields is arranged according to initial observation time. This is quite different from Montana storms, where the least active storms tend to occur in morning or early afternoon and the more active storms occur later in the day.

Table 1.--*Lightning observations, interior Alaska 1973. (Clouds with electric field)*

First Observations (Alaska daylight time)	Date	Intracloud	Cloud-to-ground	Total[2]
1113[1]	6/29	65	1	66
1143	7/4	23	0	24
1254	7/4	26	2	29
1255	6/29	1	0	1
1318	6/29	52	0	53
1359	7/5	2	0	2
1405	7/2	2	4	6
1528	7/1	3	2	5
1539	7/4	0	0	1
1533	6/30	0	0	0
1600	7/4	0	0	0
1622	6/30	0	0	0
1624	7/1	1	0	2

[1] Largest storm recorded (seeded).
[2] Includes a few discharges not identified as ic or cg.

SUMMARY

The Alaskan storms that we observed during 1973 were quite small and they produced very little cloud-to-ground lightning. The cg lightning averaged about one return stroke per discharge and only one long-continuing current discharge of the known fire-starting type was recorded. Lightning storms of this nature cause very few fires.

PUBLICATIONS CITED

Cooper, L. W., and K. E. Heikes.
1973. Cloud seeding: an approach to Alaska wildfires. 116 p. Final Rep. Contract 53500-CT3-283(N) Sierra Res. Corp. Environ. Syst. Div., Boulder, Colo.

Fuquay, Donald M.
1967. Weather modification and forest fires. *In* Ground level climatology, Am. Assoc. Adv. Sci., p. 309-325.

Fuquay, Donald M., and Robert G. Baughman,
1969. Project skyfire lightning research. 67 p. USDA For. Serv., Intermt. For. and Range Exp. Stn. Final Rep. to Natl. Sci. Found. (Grant No. GP-2617)

Fuquay, D. M., A. R. Taylor, R. G. Hawe, and C. W. Schmid, Jr.
1972. Lightning discharges that caused forest fires. J. Geophys. Res. 77(12): 2156-2158.

Hawe, R. G., and D. M. Fuquay.
1969. Remote sensing of lightning in forest fire research. p. 1193-1203. Sixth Int. Symp. Remote Sensing Environ. Proc., Willow Run Lab., Ann Arbor, Mich.

Pierce, E. T.,
1970. Latitudinal variation of lightning parameters. J. Appl. Meteorol. 9(1):194-195.

Uman, Martin A.
1969. Lightning. 264 p. McGraw-Hill, New York.

Headquarters for the Intermountain Forest and Range Experiment Station are in Ogden, Utah. Field programs and research work units are maintained in:

- Billings, Montana
- Boise, Idaho
- Bozeman, Montana (in cooperation with Montana State University)
- Logan, Utah (in cooperation with Utah State University)
- Missoula, Montana (in cooperation with University of Montana)
- Moscow, Idaho (in cooperation with the University of Idaho)
- Provo, Utah (in cooperation with Brigham Young University)
- Reno, Nevada (in cooperation with the University of Nevada)

☆ U.S. GOVERNMENT PRINTING OFFICE: 1977-0-777-023/32

U.S. DEPT. OF AGRICULTURE
NAT'L AGRIC. LIBRARY
DEC 7 '77